CONFERS Recommended Design and Operational Practices

Implementing the CONFERS Guiding Principles for Commercial Rendezvous, Proximity Operations (RPO) and On-Orbit Servicing (OOS) will begin with developing recommended design and operational practices. Adopting these practices is an effective way to enhance operational safety and mission success. The following practices represent lessons learned from prior servicing and RPO operations. These practices are intended to evolve based upon experience gained through future commercial and government servicing operations.

There are four major categories of recommended practice for servicers, operators and spacecraft manufacturers.

1. Design Servicer vehicles and operations for mission success by taking into account a layered risk mitigation and operational safety approach across the following layers:
   1.1. *Spacecraft hardware*
   1.2. *Spacecraft software*
   1.3. *Ground segment*
   1.4. *Mission operations*
   1.5. *Security*
2. Design future satellites, both servicer and potential client vehicles, to facilitate safe and effective satellite servicing
3. Share information, to the extent permissible, on successes and resolution of spacecraft anomalies.
4. Promote the long-term sustainability of space.

Recommended practices for each of these categories are detailed below.

1. Design Servicer vehicles and operations for mission success. Satellite servicers should develop a holistic approach to the design and operations of their servicing system to enhance flight safety and mission success. The system design should take into account a layered risk mitigation and operational safety approach across the following layers.

1.1. Spacecraft Hardware: The Servicer spacecraft design is fundamental to ensuring flight safety especially as related to the RPO, servicing operations and compatibility with the client vehicles (CVs). Servicer spacecraft designs should incorporate:

1.1.1. Adequate redundancy, factors of safety, margins and reliability to ensure a high probability of safely achieving mission success.

1.1.2. Validation and qualification of components to the level necessary for the mission

1.1.3. Industry-standard processes for assembly, integration and testing, including simulating a “week in the life of the spacecraft” for both hardware and software systems prior to launch

1.1.4. Adequate telemetry to facilitate the identification and probable cause of anomalies

1.1.5. Designs to ensure compatibility with the CV(s) it is intended to service across all subsystems and interfaces

1.2. Spacecraft Software for Autonomous Operations and Fault Protection: Spacecraft software should provide adequate levels of autonomy to ensure safe operations when ground control is limited by availability, throughput, reaction time, etc. This includes autonomous on-board systems to identify faults and perform appropriate recovery actions for any credible failure that can create unsafe conditions beyond the reasonable and effective control of the ground segment or operators. Such software systems should be tested according to industry standards across the full range of expected operating conditions and credible anomaly scenarios.

1.3. Ground Segment: The ground segment consists of the hardware and software systems located on Earth to allow mission operations to interface with the spacecraft. This include the Earth stations antennas & facilities, communications networks, operations centers, and the command and control software systems.

1.4. Mission Operations: Mission operations are the practices and processes established to ensure that RPO and OOS missions are performed in a safe and responsible manner. RPO and OOS servicers should develop and adopt mission operations practices and concepts of operations (CONOPS) which focus on spaceflight safety including the following:

1.4.1. *Minimize risks and consequences of mishaps*: Satellite servicing CONOPS and practices should strive to abide by the following practices to minimize the risk of mishaps occurring and the consequences if they:

1.4.1.1. Perform RPO and OOS operations for a contracted and cognizant client's space object;

1.4.1.2. For cases where no owner of the space object can be identified (e.g. space debris objects), provide adequate public notice and communication of intent with all states agencies which may have reasonably been the source of the object. If the source is identified during/following the service, notify the relevant nation states;

1.4.1.3. Use sufficient communications discipline between the servicer and client to ensure positive control of both objects during the servicing operation and discuss calibration of RPO sensors;

1.4.1.4. Use passively safe orbits, safety zones, and keep-out spheres or volumes for maneuver planning and execution during rendezvous and approach to client vehicles;

1.4.1.5. Ensure only space objects that are part of the planned operation are in the operating zone while RPO operations are underway;

1.4.1.6. Work with the proper state authorities to provide notifications of ongoing RPO operations;

1.4.1.7. Avoid physical contact with space objects other than the client space object and minimize close approaches with space objects other than the client space object;

1.4.1.8. Notify affected third parties in advance of any close approaches and exchange information necessary to support safety of spaceflight (e.g., points of contact, ephemeris, etc) while respecting intellectual property and proprietary or sensitive information;

1.4.1.9. For experimental or high-risk activities, servicers should perform initial first-time in-orbit checkout procedures and demonstrations at altitudes that minimize the consequences of mishaps on internationally recognized protected orbital zones. Servicers shall comply with the debris mitigation standards contained in ISO 24113 and any national debris mitigation standards.

1.4.2. ***Avoid physical or electro-magnetic interference***: In addition to coordination of RPO and OOS activities with client space objects, servicers should also exercise all reasonable measures to avoid physical or electromagnetic interference with other sanctioned space activities during all operational phases. Servicers should take reasonable measures to ensure that other entities (i.e., entities not associated with the RPO/OOS activities) that may have reason for concern about intentions or interference due to proximity are provided adequate notice.

1.4.3. ***Use approved and proven procedures***: Organizationally-controlled procedures along with operational guidelines, constraints and limitations are the foundation to ensure safety and success in baselining the operations plan. Approved procedures should align with the CONOPS and establish the foundation for the servicer to execute. Procedures, flight rules and test and operational limits should be reviewed and tested for completeness, correctness and safety.

1.4.4. ***Use trained and qualified operators:*** Servicer and client spacecraft operators can be critical to ensuring flight safety and enabling mission success, depending on the level of mission autonomy. Operators should be trained, experienced, and rehearsed to build confidence for safe and successful servicing missions. Consistent with mission CONOPS, operators should be notified of anomalous navigation and control conditions, system health, and mission performance, as well as manually intervene, if necessary, to limit material safety risks and hazards. Operators should prepare and practice anomaly resolution protocols.

1.4.5. ***Use of external resources*****:** Servicer should use external resources (e.g., not provided by the servicer spacecraft) to provide independent and coordinated data and information to plan and inform RPO and OOS activities. These can include external space situational awareness (SSA) and modeling or simulation capabilities. Servicers will not assume responsibility for the collection and quality of external SSA data used to perform RPO and OOS missions but CONFERS will advocate for its availability and continuous improvement as an important external resource.

1.4.6. ***Security:*** Security of ground facilities, spacecraft, mission data, and command control links are paramount across all phases of commercial satellite servicing activities. Satellite servicer spacecraft are uniquely capable of approaching and interacting with other satellites and thus could draw significant interest for cyber attacks. Commercial satellite servicing systems should provide adequate security to prevent unauthorized access and ensure access to telemetry and commanding by operators to maintain positive control and safe operations. Cyber security will be conducted to meet or exceed current and developing cyber security standards.

2. **Design satellites to facilitate safe and effective satellite servicing.** Satellite servicer spacecraft should be designed in such a way as to facilitate the safety and effectiveness of commercial satellite servicing activities. Servicer spacecraft and future client spacecraft designs should include methods to improve their ability to be tracked, grappled, and serviced, by incorporating cooperative servicing interfaces such as: optical fiducial markers, beacons, grappling fixtures, fluid transfer interfaces, and power/data modular separable interfaces.

   2.1. Satellite manufacturers and servicing interface developers should share as much information as practical about the physical design, mounting location, and method of operation of their interfaces to improve safety and compatibility.

   2.2. Servicing interfaces should be designed and installed on a client spacecraft in a way to minimize the probability of releasing secondary debris in the course of servicing operations. This is particularly important for grappling fixtures, which should be designed and installed in a location where the client spacecraft can be safely grappled even in an uncontrolled or tumbling condition

   2.3. Manufacturers should take closeout pictures of serviceable areas of a client spacecraft to aid planning and execution of safe and effective servicing.

   2.4. Thermal blanket closeouts or other coverings over serviceable interfaces should be designed for robotic uncovering/recovering.

   2.5. Where possible, grappling mechanisms and modular separable interfaces should be designed with a redundant way of releasing in case the primary method fails.

3. **Share information on resolution of spacecraft anomalies/failures and related root cause analysis.** Spacecraft anomaly/failure detection, resolution, recovery and attribution are critical to improving the safety, reliability, and transparency of satellite operations. Servicers and servicing operations will benefit from clear anomaly attribution and can also potentially contribute to attribution assessments during their operations. While competition is essential to a healthy satellite servicing sector, it is also in the best interest of the servicing community to abide by the following practices to help prevent anomalies and failures that could undermine trust in the servicing community:

   3.1. Develop and share best practices for the anomaly attribution processes within the servicing community while abiding by national export control laws and proprietary business confidential/intellectual property restrictions.

   3.2. Participate in the development of anomaly resolution standards and sharing frameworks.

   3.3. Share information within the satellite servicing community on specific examples of anomaly resolution and attribution that could impact the community as a whole, to the extent it is practical while abiding by national export control laws and proprietary business confidential/intellectual property restrictions.

4. **Promote the long-term sustainability of space activities.** Members of the Consortium believe that a well-maintained space environment is essential to the success of the industry and that the long-

term sustainability of the space environment should be considered at every step. Members should strive to:

4.1. Comply with relevant internationally-recognized guidelines and standards for the long-term sustainability of space activities, including those developed by the Inter-Agency Space Debris Coordination Committee (IADC), United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS), International Organization for Standardization (ISO), and the Consultative Committee for Space Data Systems (CCSDS).

4.2. To the extent allowed by law, collaborate with State authorities and the broader space community to identify emerging space sustainability challenges and participate in the development of future guidelines and standards that enhance space sustainability.